RELATIONSHIPS OF THE OPALINIDA WITH PARTICULAR REFERENCE TO *PROTOOPALINA* (PROTOZOA)

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ABSTRACT

Relationships of the Opalinida to other Protozoa and the classification of the Opalinida are reviewed. Evolution of the Protoopalinidae occurring in frogs of the family Hylidae is discussed.

INTRODUCTION

The classification of opalinids has long been an enigma for protozoologists. Attempts to explain relationships have resulted in many classifications since van Leeuwenhoek described the Protozoa in 1683 (Wessenberg 1961). A review of the major developments in this persistent puzzle demonstrates some of the changes in recent years.

In the last twenty-five years several investigators have changed the classification proposed by Metcalf (1923, 1940), which considered the opalinids as "Protociliata". Raabe (1948) created the Opalinata as a class of the flagellates and placed it alongside the class Hypermastigina. Lwoff and Valentini (1948) and later Fauré-Fremiet (1950) also considered the opalinids as flagellates because of their homokaryote condition and supposed interkinetal division. Grassé (1952) considered the Opalinida as a super-order within the superclass Flagellata (thus following Fauré-Fremiet's recommendation) and so separated them from the ciliates. Wessenberg (1961) has questioned the validity of this interpretation by showing that both interkinetal and perkinetal divisions are found in both flagellates and some ciliates. He has also suggested that ciliate conjugation is a modification of syngamy, and that patterns of ontogeny similar to that in the opalinids may be found in both ciliates and flagellates, and that although the homokaryote condition may be flagellate-like, the multi-nucleate condition may be protociliate.

Wessenberg (1961) concluded that opalinids showed both flagellate and ciliate affinities but that they were a distinct group. He therefore suggested retaining the name Opalinata and placed the group in a position intermediate between the ciliated and flagellated protozoa.

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Corliss and Balamuth (1963) agreed with Wessenberg (1961) and raised the Opalinata to the level of superclass in a taxonomic position between the true ciliates and true flagellates. The establishment of a new superclass within the sub-phylum Sarcomastigophora emphasized the remoteness of the opalinids from the true flagellates but avoided making the class an appendage group.

The opalinids are now considered to occupy a position essentially equivalent to the ciliates and the flagellates and are placed somewhere between them (Honigberg *et al.* 1964). This classification satisfies the taxonomic evidence available to date and does not imply a closer association with either the ciliates or the flagellates.

THE RELATIONSHIPS OF *PROTOOPALINA*

Metcalf (1940) reviewed the classification of the order Opalinida and indicated the probable relationships of the genera in a phylogenetic diagram (Fig. 1). The genus *Protoopalina* is

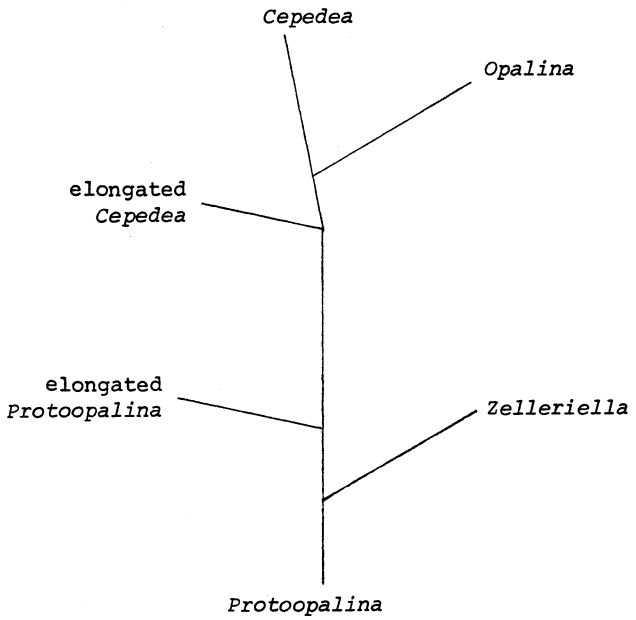

Fig. 1. Phylogeny of the order Opalinida

considered archaic both because of its wide geographical distribution and because of its morphological agreement with the first stages in development of *Zelleriella, Cepedea* and *Opalina*. *Protoopalina* and *Zelleriella* are binucleate and the former, which is circular in cross-section is considered to have given rise to the latter. The other two genera are multinucleate, with the flattened *Opalina* probably having arisen from *Cepedea* which is circular in cross-section.

Metcalf (1928, 1940) believed that the protoopalinids present in Australasian frogs of the family Hylidae are in fact remnants of protozoa which passed through Australia to New

Zealand in ancestors of the primitive anuran family Ascaphidae [1] (Fig. 2). The present protoopalinids in the Hylidae have arisen

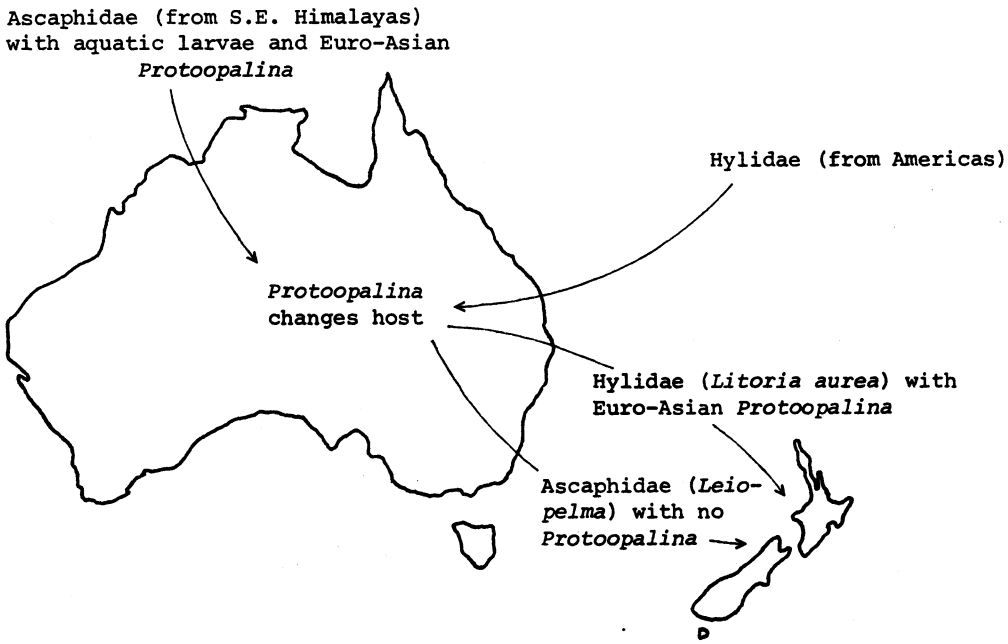

Fig. 2. Schematic description of probable pathways taken by Australasian *Protoopalina* and its anuran hosts.

from what Metcalf terms a Euro-asian stock, whereas the Hylidae are of tropical and southern American origin. Stejneger (1905) suggested that the ascaphids (of which *Leiopelma* is a present-day representative found in New Zealand) had their origins in the eastern end of the Himalayas. The ancestors of *Leiopelma* are postulated to have crossed a land bridge from south eastern Asia to Australia and carried on to New Zealand in the late Jurassic - early Cretaceous period. If however some of their derivatives remained in Australia until the late Cretaceous - early Tertiary period then they could have been in contact with the Hylidae (and Leptodactylidae) arriving from the Americas. An exchange of opalinids could then have taken place between the host families.

The Australian tree frog, *Litoria aurea* (Lesson, 1830) probably was first introduced to New Zealand in 1867 (McCann 1961), and brought with it its protozoan fauna including *Protoopalina hylarum* (Raff, 1911) which is presumed to have been derived from protozoans occurring in ancestral Ascaphidae.

The present species of *Leiopelma* do not have an aquatic larval stage (Stephenson 1961) and therefore have no pathway by which an opalinid reinfection could occur. Because of their highly modified life cycle they possess no opalinids (Metcalf 1928, Stephenson pers. comm.). It is interesting to note that

1. The family name Leiopelmidae is used by some authorities.

the closest living relative of *Leiopelma*, *Ascaphus*, possessed opalinids of a Euro-Asian form but only in the tadpole stage. The presence of both an aquatic larva and opalinids in *Ascaphus* shows the likelihood of ascaphid ancestors bearing proto-opalinids.

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LITERATURE CITED

CORLISS, J.O. and BALAMUTH, W. 1963. Consideration of the opalinids as a new superclass in the Subphylum Sarcomastigophora. *Journal of Protozoology 10* (Supplement): 26. (Abstract)

FAURÉ-FREMIET, E. 1950. Morphologie comparée et systématique des ciliés. *Société zoologique de France Bulletin. Paris. 75*: 109-122.

GRASSÉ, P.P. 1952. *Traité de Zoologie*, Tome 1, Fascicule 2, Masson et Cie, Paris.

HONIGBERG, B.M., BALAMUTH, W., BOVEE, E.C., CORLISS, J.O., GOJDICS, M., HALL, R.P., KUDO, R.R., LEVINE, N.D., LEOBLICH, Jr., A.R., WEISER, J., and WENRICH, D.H. 1964. A revised classification of the phylum Protozoa. *Journal of Protozoology 11*: 7-20.

LWOFF, A., and VALENTINI, S. 1948. Culture de flagellé opalinidae *Cepedea dimidiata*. *Annales de l'Institut Pasteur. Paris. 75*: 1-7.

METCALF, M.M. 1923. Opalinid ciliate infusorians. *Bulletin. United States National Museum. Smithsonian Institution. Washington. 120*: 1-484.

———— 1928. Trends in Evolution. *Journal of Morphology and Physiology 45*: 1-45.

———— 1940. Further studies on opalinid ciliate infusorians and their hosts. *Proceedings of the United States National Museum 87*: 465-634.

McCANN, C. 1961. The introduced frogs of New Zealand. *Tuatara 8*: 107-120.

RAABE, Z. 1948. An attempt of a revision of the system of Protozoa. *Annals of the University of Mariae Curie - Sklodowska Lublin - Polonia Section C (Biology) 3*: 259-276 (Polish-English summary).

STEJNEGER, L. 1905. The geographical distribution of the bell toads. *Science 22*: 502.

STEVENSON, E.M. 1961. The New Zealand native frogs. *Tuatara 8*: 99-106.

WESSENBERG, H. 1961. Studies on the life cycle and morphogenesis of *Opalina*. *University of California Publications in Zoology 61*: 315-370.

FAURÉ-FREMIET, E. 1950. Morphologie comparée et systématique des ciliés. *Société zoologique de France Bulletin. Paris. 75*: 109-122.